THE USE OF ROD MILLS IN THE BEATING OF KRAFT PULP

By

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In February, 1928, the first 7 by 16 foot Marcy rod mill of the open-end, low pulp-line type was started on sulphate stock at our plant. At that time the total production of sulphate pulp amounted to about 60 tons per day. The pulp was pumped from the diffuser stuff chest through a knotter and centrifugal screen to an Oliver filter where it was thickened to about 10 per cent consistency. A screw conveyor conveyed it to the rod mill which gave the pulp a preliminary beating with a power consumption of 185 horsepower after a few weeks operation. From the outlet of the mill the pulp dropped into a stuff chest from where it was either pumped to the beaters or run into laps.

During the first two months of operation, exhaustive tests were run to ascertain the results obtainable and the operating conditions for most effective service. In brief, these tests indicated that this size of mill gave the best results with a flow of pulp at the rate of between 45 and 60 tons per day. The consistency for best results was between 5-1/2 and 6-1/2 per cent and the rod charge 45 tons of 3, 2-1/2, and 2 inch rods which filled the mill to within 8 inches of the horizontal plane through the center of rotation. The speed of the mill was 12-1/2 r.p.m.

When running with a feed of 50 tons of air-dry sulphate pulp per day, the bursting strength as shown by laboratory formed sheets, was raised from 35 to 108 per cent with a tearing test of 164 per cent. The same kind of pulp in 1-ton beaters taking 100 horsepower required 3 hours to reach the same test. The horsepower hours required per ton of pulp for each kind of equipment to develop the same test figured as follows:

Beaters........... 300 horsepower-hours
Rod mill........... 89 horsepower-hours

Two months after the first mill commenced operation two more were ordered to take care of the additional production expected in August. These mills have been in operation since then and each mill has handled a flow of about 50 tons. They have made possible the changing of the production of a four-machine paper mill over from a mixture of sulphite and sulphate pulps to an all sulphate pulp furnish without adding any additional beating or refining capacity. Some beaters have been rebuilt, however, and some old jordans have been replaced by new, but the power used in beating and refining has not been increased over that used by the rod mills. The distribution of power between rod mills, beaters, and jordans is approximately as follows:

<table>
<thead>
<tr>
<th>Rod mills</th>
<th>555 horsepower</th>
<th>15.7 per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beaters</td>
<td>1000 horsepower</td>
<td>28.1 per cent</td>
</tr>
<tr>
<td>Jordans</td>
<td>2000 horsepower</td>
<td>56.2 per cent</td>
</tr>
<tr>
<td>Total</td>
<td>3555 horsepower</td>
<td>100.0 per cent</td>
</tr>
</tbody>
</table>

In testing rod-milled stock in the laboratory beater against the same stock taken before the rod mill, it has been observed in about four series out of five that the former will develop a higher maximum and at a point about 15 minutes earlier than the latter. Figure 1 shows two strength-development curves for the same stock taken before and after the rod mills and developed in the laboratory beater in the customary manner.

**Used on Bleached or Unbleached Stock**

Since the rod mills have been installed it has been found possible to screen with larger perforations, thereby materially increasing the capacity of the screens. Hand sheets made of the stock before and after the rod mills show a marked improvement in the stock. Not only has it been found advantageous in stock to be used unbleached but in stock that is subsequently bleached or partially bleached. Shives are broken up to their ultimate fibers so that the bleach reaches each fiber simultaneously with more uniform results and a marked reduction in bleach consumption. No fiber debris is produced, however, so that the mechanical loss in washing is not affected. Jordaning before bleaching was found to produce a marked increase in fiber loss. In the manufacture of partially bleached pulps the preliminary beating with a rod mill is particularly advantageous because otherwise the shives are particularly prominent.
FIG. 1.

Strength development in laboratory beater
After ascertaining the advantages of running the stock through one rod mill, the possibilities of passing it through two rod mills in series naturally comes to mind. The three rod mills were ready for operation before the full production of the pulp mill was reached and advantage of the fact was taken to run two in series with a flow of 60 tons of pulp per day through them for a period of nine weeks. After this period the three mills were run in parallel with a flow of 45 tons through each. The strength tests on all the paper made during the nine weeks' period were tabulated against the tests made during the next five weeks. The results of double rod milling in paper ranging from 20 to 58 pounds per ream were as follows:

- Speed was increased .............. 1 per cent
- Bursting strength was increased .... 6 per cent
- Tearing strength was increased ...... 8 per cent
- Sheet density was decreased ....... 20 per cent

For the heavier weights the number of runs were so few as to have no statistical significance on account of the element of chance which always prevails where the number of variables are great as in paper making.

In the case of test liner the speed of making 0.016-inch caliper board was increased 8 per cent and 0.012-inch caliper board 13 per cent. An analysis of the power consumption in horsepower-hours per ton compared with strength of paper gave the following results:

<table>
<thead>
<tr>
<th>Apparatus used</th>
<th>Process A</th>
<th>Process B</th>
<th>Process C</th>
<th>Process D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rod mills</td>
<td>No rod</td>
<td>One rod</td>
<td>Two rod</td>
<td>Two rod</td>
</tr>
<tr>
<td>Beaters</td>
<td>163</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jordans</td>
<td>332</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total power</td>
<td>495</td>
<td>597</td>
<td>649</td>
<td>588</td>
</tr>
<tr>
<td>Sheet strengths</td>
<td>Bursting: 0.90</td>
<td>0.95</td>
<td>1.00</td>
<td>1.05</td>
</tr>
<tr>
<td></td>
<td>Tearing: 160</td>
<td>178</td>
<td>194</td>
<td>214</td>
</tr>
</tbody>
</table>

Power distribution
Power Consumption

The first three columns are from actual performance. Since these tests it has been found that the jordans have been overrefining the stock on a large proportion of the runs so that the last column is hypothetical but based on single tests run at the rate of 45 tons based upon what has been since found to be the proper amount of power to apply with the reduced power consumption and are based on average weights of from 40 to 60 pounds per ream 24 x 36 - 480 sheets.

Analysis of the results naturally suggests the question why use the beaters? In the operation referred to the beaters are there and are necessary on account of frequent changes in furnish, color, etc. Where long runs of natural colored or lightly colored kraft are made, the beaters could be dispensed with and the power saved which they consume without marked reduction in test. A machine making 60 tons of kraft paper per day could undoubtedly be effectively taken care of with a series of three 7 by 16 foot low pulp-line rod mills taking 185 horsepower each and two jordans taking 300 to 350 horsepower each and the paper produced would be equal to that produced by any combination of beaters and jordans. The three rod mills will develop more strength in the first half of the beating operation than a series of jordans taking from two to three times the power. Microscopic examination indicates that even after triple rod milling there is absolutely no cutting of the fibers as can be seen in photomicrographs shown in Figures 2, 3, 4, 5, and 6, taken from a run last summer with the three mills in series. Fragments of medullary rays are evident in all of them but even in Figure 4 showing pulp taken after the third rod mill the fibers are still intact. They are much more flattened, however, like ribbons and the bordered pits have been lengthened and narrowed so that after treatment with the jordans as shown in Figure 5, a beautiful development of fibrillae results, and still with very little production of cut-off ends.

The paper made from the triple rod-milled stock had a bursting strength 15 per cent greater and was run on the paper machine 15 per cent faster during a period of 5 hours than paper of the same weight during the previous 8 hours when running on single rod-milled stock. The power taken by the two additional rod mills was compensated by the power saved by backing off the jordans and the larger production per hour.

Before the installation of the first mill some concern was felt as to whether the heavy rod charge necessary to obtain the best efficiency with a 7 by 16 foot mill would

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See Plate II, following p. 79.
reduce the maximum strength developable from the fibers. The rod charge is double what has been used to date in beating paper pulp, and the power requirement is also double. No evidence whatever of injury has been detected and the maximum strength developed afterward in the beaters or jordans has been repeatedly found to have been increased. The added diameter of mill, however, with the larger charge of longer rods gives three times the beating effect with the consumption of twice the power required by the smaller mills hitherto used in this field.

Conclusions

In conclusion the experience in beating kraft pulp with low pulp-line, open-ended rod mills 7 feet in diameter inside the lining and 16 feet long would indicate that for the first third of the beating operation the beating effect per horsepower is from two to three times as great as by beaters or jordans. For the second third of the beating operation the beating effect is from 50 per cent greater to twice as great as with beaters and jordans. For the final third of beating or refining the jordan type of engine is more adaptable and as efficient in the use of power as the rod mill. When operating at pulp consistencies above 5-1/2 per cent and with feeds above 40 tons per day, there is no detectable reduction in maximum strength developable and usually there is an increase over that possible with beater alone. Discoloration of the pulp is little if any greater than the darkening inherent in development of felting strength regardless of how it is done. The upkeep of a mill with 45-ton rod charge amounts to less than 4 tons in a period of two years. So far the wear on the linings appear to be negligible. Taken all together this type of mill has outstanding advantages in this field and is worthy of attention from all kraft paper or board manufacturers.